
Value Recovery from Two Mechanized Bucking Operations in the Southeastern United States

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ABSTRACT: *The value recovered from two mechanized bucking operations in the southeastern United States was compared with the optimal value computed using an individual-stem log optimization program, AVIS. The first operation recovered 94% of the optimal value. The main cause for the value loss was a failure to capture potential sawlog volume; logs were bucked to a larger average small end diameter than necessary. The result was that a portion of the stem with potential sawlog volume was being converted into lower value pulpwood. Although the value loss was relatively small, the length measurements were outside of the acceptable range and the machine needed to be recalibrated. The second operation recovered only 58% of the optimal value. The main cause of loss was poor length measurement, producing a number of short logs that would have been rejected as chip-and-saw logs. Statistical quality control charts from both operations show that logs were being cut too long for the first operation studied and too short for the second operation. These low cost control methods should be required for monitoring mechanized bucking operations. We believe they will help to reduce the value lost from inconsistent measurements. South. J. Appl. For. 27(4):259–263.*

Key Words: Value recovery, bucking, control charts.

Cut-to-length systems have the ability to reduce environmental impacts when compared with conventional stem-length harvesting systems. They carry the entire log with articulated machinery, often over a protective mat of branches resulting in less soil and residual stand damage (Lanford and Stokes 1995). Trees are processed near the stump instead of at central processing areas allowing nutrients to be maintained on site, and less area is removed from production for landing construction. These benefits do not come without additional costs. Cut-to-length harvesting systems have a higher purchase price when compared to tree-length systems of feller-bunchers and skidders. In the western United States, they have also been shown to have lower production rates (Anonymous 2000). This combination of higher purchase price and lower production rates results in higher operating costs than are associated with conventional stem-length harvesting systems.

Companies have traditionally relied on cost reduction to maintain profitability. Murphy and Cossens (1996) promote

management of value recovery, where the objective is to maximize revenue while controlling costs, as an alternative means to maintain or potentially increase profits. This requires that harvesting managers must collect both value recovery and operating cost information to effectively monitor their business performance.

Focusing on value recovery is not a new concept. Almost a century ago, R.C. Bryant, in his 1913 textbook on American logging practices, commented that insufficient attention was being given by log makers to securing quality as well as quantity. He noted that an increase in the percentage of higher grades, more timber per acre and a prolonged life to the operation through greater profits, was to be gained from a change in focus. Over six decades later, Conway (1976) commented that “least cost ... unfortunately still is in all too many cases, the main objective” for many American logging operations. He also noted that focusing on end use and value could result in millions of additional dollars per year for the forest industry.

The New Zealand forest industry has had a focus on value recovery for over two decades. The initial value recovery studies in New Zealand indicated that 40% of the total stem value could be lost during harvesting operations (Murphy and Twaddle 1986). The largest single source of loss was from bucking where up to 26% of the potential value could be lost.

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It should be noted that in the early 1980s, most bucking was accomplished manually with a chainsaw. Other sources of loss included felling damage, high stumps and butt-log damage (Murphy and Twaddle 1986). As workers were trained and provided with the proper tools, a rapid improvement was made with value losses reduced to 11% of the potential stem value (Murphy et al. 1991).

In Oregon, a network optimization approach (BUCK) was developed to improve value recovery. It was used in several studies on manual bucking in the Pacific Northwest; one documented a \$158 per tree improvement in value recovery when bucking logs from old-growth trees and a \$10 per tree improvement for second-growth trees (Sessions et al. 1989). In another study, a 14.2% increase in value was found when BUCK was applied to 50 old-growth trees (Garland et al. 1989). In central Oregon, the results from three studies showed 5.2, 6.3, and 7.3% improvements in value recovery using BUCK (Olsen et al. 1997). Similar results were produced in western Oregon with a 9.5% increase in volume and a 9.3% increase in value on 85 trees when the optimal solution was compared with an experienced log maker. The net value recovery, after additional labor costs were deducted, showed a 6.5% per tree increase (Bowers 1998).

Olsen et al. (1989) also showed that value recovery improvements were available when buckers were provided with the proper tools; a 5.2% increase in value was found when diameters were measured with a caliper instead of a tape. The caliper produced more accurate diameter measurements.

These studies have demonstrated that potential value gains exist from improved manual bucking. There has been a shift in bucking from motor-manual methods to mechanized systems, however, to secure increased production and improved safety opportunities. Sondell (1995) compared the value recovered from five different mechanized bucking systems. All five systems were within 4% of the optimal solution. There were problems with length measurement, however; between 11% and 32% of logs were outside the "accepted" tolerance of 2.5 to 5.0 cm.

A similar study was completed in New Zealand where five mechanized bucking systems were compared with two manual bucking methods. The mechanized systems included two Denis DM 3000 machines, one Denis DM 3500, two Hahn processors, and one Waratah HTM 234. The results showed that the mechanized operations produced similar results to the manual bucking systems with regard to diameter measurements, but showed much larger errors due to length measurements (Evanson 1995).

Another study in New Zealand evaluated a Hahn harvester and found that 90.3% of the potential stem value was recovered when producing saw logs and pulp. Eighty-three percent of the lengths measured were within 5 cm tolerances. Conservative diameter measurements were the main cause for the 9.7% value loss (Cossens 1991). A Hahn harvester was also studied in Oregon and the value from 25 trees compared with the optimal solution. There was a 7.5% loss in value from the mechanized log processing. The optimal solution contained more small logs, taking advantage of the Scribner scaling

rules (Olsen et al. 1991). Scribner scaling rules were not utilized by the merchandising system that was being used in the Hahn harvester at that time. This clearly shows the importance of having the merchandising machine aligned with the volume calculations, whether it is cubic meters or the various board-feet log rules.

Statistical quality control (SQC) charts have been used by a number of industries as a means of monitoring system performance. SQC continually monitors a process by comparing the mean of a sample to a collection of means with known standard deviations from a process considered in-control. SQC are always represented as graphs with time on the X-axis and the results of the sample measurements on the Y-axis. There are three control lines in most SQC charts. The centerline is the mean determined from a process considered in-control. The upper and lower values are typically three times the standard deviations from the mean for an in-control process. Samples are taken periodically during the manufacturing process and if the mean value from the sample is outside of the control limits, then the process is said to be out-of-control. If the process has a series of consecutive points above or below the mean value, the process can be considered out-of-control (Montgomery 1985). SQC have been used in sawmills to monitor lumber size control (Brown 1982). It has been suggested that SQC charts, based on percentage of optimal value recovery or on proportion of logs conforming to specification, could be used to monitor value recovery performance (Murphy and Twaddle 1986, Copithorne et al. 1994).

Methods

The project's first goal was to compare the percent value recovery from selected southeastern United States operations with other published results. At the time of this study there were limited operations working in mechanized bucking. Two logging operations agreed to be studied and were measured. One was a final harvest operation (FH) in Arkansas. The average stem volume was 1.45 m³. The other was a first thinning operation in Florida (THIN). The average stem volume was 0.07 m³. Both operations were in loblolly pine plantations and were measured during the summer of 1999. Operation FH produced five allowable length classes for the saw log grade and a variable length pulpwood grade. Logs were made using a Waratah processor head on a tracked machine. Operation THIN produced two sorts of logs: a 5.2 m chip-and-saw log and a variable length pulp log. A Hahn processor head on a tracked vehicle was used.

Forty-six and 47 stems were measured for operation FH and operation THIN, respectively, for the purpose of comparing the actual value recovered and the theoretical optimal value as found using the log optimization system, AVIS (Geerts and Twaddle 1985). These stems were randomly selected for each operation.

AVIS is a dynamic programming system that maximizes the total value of individual stems based on the allowable grades a mill or group of mills are accepting. Log grades are defined by several log characteristics such as small-end diameter, knot size, defects due to excessive sweep, stem

damage, or forked tops. Following the bucking, the length, grade, and small-end diameter (SED) were recorded. To protect confidentiality of the companies participating in the study, average log prices for the southeastern United States for summer 1998 were used as a basis for valuing the log products cut from each stem (Timber Mart-South 1998).

The second goal of the study was to evaluate the use of SQC charts as a means of monitoring value recovery performance. We chose to use SED and length accuracy as surrogates for value recovery for this study since they are: simpler to measure; are an indicator of value loss; and are common components in log specifications set by most mills. Samples of six logs were measured hourly at each study site. This resulted in 20 samples for the THIN operation and 14 samples for the FH operation. Very precise machines may produce control limits with a narrower range than the mill specifications. Few managers would select a bucking system whose natural control limits were larger than the mill tolerances as most logs would be rejected. For this study, the operations were assumed to be in-control with target length equal to mean value, and the mill tolerances were assigned to upper and lower control limits equal to three times the sample standard deviations.

Results and Discussion

Value Recovery Performance

Operation FH recovered 94% of the potential value determined by AVIS from the stand by capturing 93% of the estimated optimal sawlog volume (Table 1). Nineteen of the 46 stems were manufactured differently than the solution generated from AVIS. Operation THIN recovered 58% of the potential value, with 30 of the 47 trees showing log-manufacturing losses. A substantial source of the value loss in Operation THIN resulted from downgrading potential sawlogs to pulp grades; only 37.5% of the estimated sawlog volume was recovered.

These results were compared with published studies and unpublished audits of 31 mechanized operations and the average of 48 manual bucking operations (Murphy 2002). They show that the percentage value loss for Operation FH is one of the better results found, while the opposite is true for Operation THIN (Figure 1). This comparison has not been normalized based on the number of grades from which each operation had to select, since research by Parker et al. (1995) indicates that number of log grades has little influence on bucking errors below 10 grades.

Statistical Quality Control Charts

The main cause for the value loss from Operation FH was a failure to cut sawlogs near the minimum allowable SED. On

Table 1. Comparison of optimal and actual volume and value recovery for two harvesting operations in the southeastern United States sampled in 1999.

Operation	Sample size	Optimal value	Actual value	Optimal sawlog volume	Actual sawlog volume
	(\$)(m ³)
FH	46	6,500.00	6,113.60	64.1	59.7
HIN	47	206.00	119.00	1.6	0.6

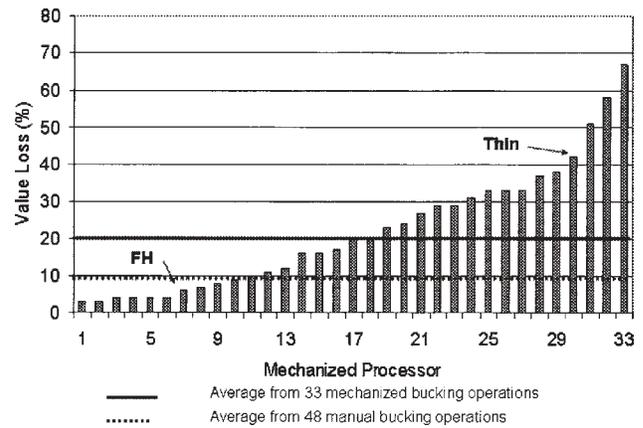


Figure 1. Comparison of value loss from mechanized log making studies (Source: Murphy 2002).

average, the sawlog SEDs from the optimal solution were 3.1 cm smaller than those for the actual solution (Figure 2). This is a common mistake among buckers as they try to reduce the likelihood of the logs being rejected for not meeting the mill's log specifications.

The results of the length measurements from the quality control charts show a similar conservative pattern with most sample means being longer than the target value, and four samples being longer than the log specification bounds (Figure 3).

Poor length measurement by the mechanized bucking system was the main cause for poor performance for Operation THIN. Only 7 of the 20 samples had mean sample lengths within a 5 cm tolerance, calculated using the desired length based on the adjusted log specifications (Figure 4). It is important to note that these adjusted tolerances are based on the standard deviations and sampling information and do not necessarily relate to mill specification limits.

These results were similar to those reported by Evanson (1995) for a Denis 3000, where 47% of the stems measured did not meet the 3 cm length tolerances. The errors in length measurements were worse than the poorest performance reported by Sondell (1995) for his studies on operations in Scandinavia where at least 68% of the logs produced met specification. Large numbers of logs which do not meet specification could result in many rejected loads causing both

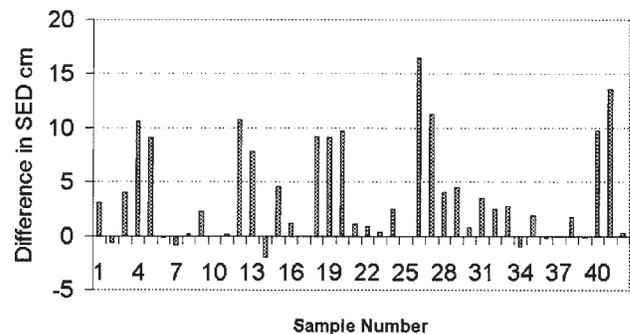


Figure 2. Difference between small-end diameters (SED) from the optimal and actual solutions.

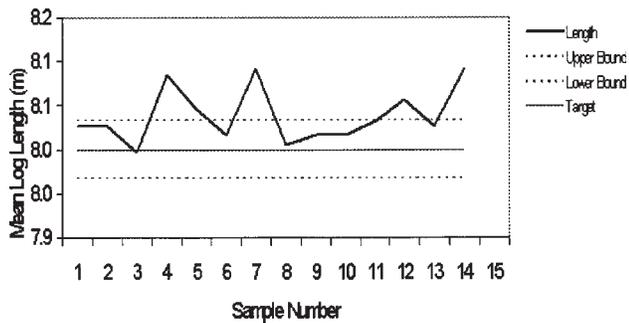


Figure 3. Comparison of mean log lengths with process control specification for an 8 m target length for Operation FH.

a loss in value when sold as pulpwood, and an increase in costs with the additional hauling from one facility to another. The outcome would be reduced profits from the thinning operation. Some mills will reject a load if any one log is out-of-specification. Others may reject only those individual logs that do not meet specification.

Discussion and Conclusions

The value recovered from Operation FH's cut-to-length harvesting system was similar to some of the better operations found elsewhere in the world. Losses in value were primarily caused by conservative SED measurements and an inability to control length measurements. In relative terms, Operation THIN showed substantially larger value losses than those found for Operation FH. The losses were primarily due to poor length measurements resulting in much of the higher value chip-and-saw logs being reduced to pulp logs. Operation THIN's value recovery was also at the bottom end of performance found around the world.

Although SQC charts based on length and SED do not provide a direct quantitative measure of value recovery, the information they contain can be used to monitor surrogates for value recovery, since they provide a measure of compliance with log specifications. A SQC chart demonstrated that Operation FH was being conservative by making logs consistently longer than the target specification. Operation THIN's statistical quality control chart clearly demonstrates that the length measurements were from a process that was out-of-control.

We acknowledge that these are preliminary results from value recovery studies of only two operations in the southeastern

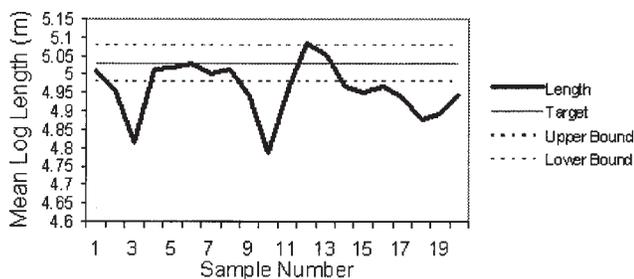


Figure 4. Comparison of mean log lengths with process control specification for a 5.02 m target length for Operation THIN.

United States and the results may not be representative of "typical" operations. No statistical sampling system was developed to ensure that these results would be applicable to the entire population of mechanized log-making in this region of the United States. We believe this study has indicated that further work is warranted in this region. It shows that potential improvements in value recovery exist for some mechanized operations in the southeastern United States, particularly since the results from THIN were lower than those found in the first operations studied in New Zealand (Murphy and Twaddle 1986). We recommend that further value recovery studies be undertaken to broaden the knowledge base in this area.

Experience from outside the region, when combined with results from this preliminary study, would also suggest that value recovery from mechanized operations should be monitored and managed at least as well as costs are managed. Statistical quality control charts, based directly on potential value, should ideally be maintained for all mechanized bucking operations as a method to control bucking practices and to improve value recovery. Alternatively, statistical quality charts based on log features such as small end diameter and length should be maintained to ensure compliance with log specifications.

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